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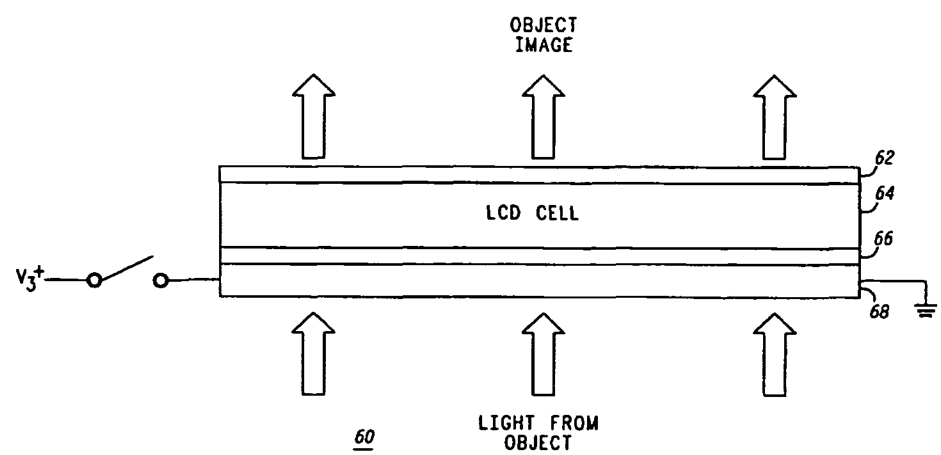
(54) Title: DOUBLE-SIDED VIEWABLE DISPLAY WITH SWITCHABLE TRANSFLECTOR



(57) Abstract: A system and/or method for providing a LCD device (10) with a transflector portion that has a reflective state and a transparent state. Two transflector portions (12, 20) are provided to form a device with a double-sided display or one transflector portion (68) is employed to provide a display with a displaying state and a transparent state.

WO 02/071131 A2

DOUBLE-SIDED VIEWABLE DISPLAY WITH SWITCHABLE TRANSFLECTOR

Technical Field

The present invention generally relates to display systems, and more particularly to a system and method for providing a display with a transflector portion that is selectable between a reflecting state and a transparent state.

Background Art

Liquid crystal displays (LCDs) are commonly used as display devices for equipment such as portable televisions, notebook computers, cellular telephones and other portable electronic devices. A conventional LCD includes a plurality of LCD elements forming a plurality of rows and columns, each LCD including a pixel electrode and a common electrode with a portion of liquid crystal material disposed therebetween. Furthermore, conventional LCDs employ a reflective mode which requires a predetermined minimum ambient light intensity to be available for providing sufficient contrast ratio in the display for satisfactory interpretation of the display by an observer.

More generally, conventional LCDs comprise a layered assembly comprising a top polarizer, a top substrate, a top electrode, a liquid crystal, a predetermined pattern or array of bottom electrodes, a bottom substrate, a bottom polarizer, and a reflector (transflector). The polarizers are aligned with axes at right angles to each other in an orthogonal relationship. The principles of operation of LCDs are well known in the art. One such principle is that LCDs operate by reducing transmissibility of light through a thin layer of liquid crystal material when an electric field is applied.

Many conventional LCDs employ a reflective or transflective portion on an opaque background that only functions in a reflective state. Some conventional LCDs, such as some clocks, are operated in a transmissive mode with a transparent background. Conventional LCDs are also readable only on a single side. Therefore, information needed to be displayed on a device, for

example, that is closed during non-use such as a cell phone, can only display information by providing a second alternate display with circuitry to operate this display. A second alternate display and additional circuitry can be prohibitive in both cost and size.

Brief Description of Drawings

FIG. 1 illustrates a schematic block representation of a side view of a double-sided display in accordance with one aspect of the present invention;

FIG. 2 illustrates a front view of a portable communication device in an open state employing a double-sided display in accordance with one aspect of the present invention;

FIG. 3 is a functional schematic block representation of components employed for viewing material in a front display of the portable communication device of FIG. 2 in the open state in accordance with one aspect of the present invention;

FIG. 4 illustrates a front view of the portable communication device of FIG. 2 in a closed state employing a double-sided display in accordance with one aspect of the present invention;

FIG. 5 is a functional schematic block representation of components employed for viewing material in a rear display of the portable communication device of FIG. 2 in the closed state in accordance with one aspect of the present invention;

FIG. 6 is a schematic block diagram of a drive system employed for driving a double-sided display in accordance with one aspect of the present invention;

FIG. 7 illustrates a schematic block representation of a side view of a single sided display in a transparent state in accordance with one aspect of the present invention;

FIG. 8 illustrates a schematic block representation of the single sided display of FIG. 7 in a reflective state in accordance with one aspect of the present invention;

FIG. 9 is a flow diagram illustrating one particular methodology for displaying material on a front side or a rear side of a double-sided display in accordance with one aspect of the present invention; and

FIG. 10 is a flow diagram illustrating one particular methodology for displaying material or providing a clear window of a single sided display in accordance with one aspect of the present invention.

Disclosure of the Invention

The present invention relates to a system and/or method for providing an LCD device with a transflector portion that has a reflective state and a transparent state. Two transflector portions can be provided to form a device with a double-sided display or one transflector portion can be employed to provide a display with a displaying state and a transparent state. While the following description of one aspect of the present invention primarily relates to portable communication devices, it will be understood and appreciated by those skilled in the art that a system and/or method in accordance with the present invention also may be implemented in conjunction with other types of display implementations.

FIG. 1 illustrates a block diagram side view of a double-sided viewable display 10 according to one aspect of the present invention. The double-sided viewable display 10 includes a first transflector portion 12 disposed on a first side of an LCD cell 14 and a second transflector portion 20 residing on a second side of the LCD cell 14. A first polarizer 13 resides between the first transflector portion 12 and the first side of the LCD cell 14 and a second polarizer 18 resides between the second transflector portion 20 and the second side of the LCD cell 14. The LCD cell 14 is formed from a liquid crystal layer 16, for example of a twisted nematic type, disposed between a first electrode 15 and a second electrode 17. The first and second electrodes 15 and 17 both include a pattern or array of transparent electrodes. The first and second polarizers 13 and 18 are employed to polarize ambient light in an X and a Y direction that passes through the polarizers 13 and 18. The use of polarizers in twisted nematic (TN) and (STN) LCD devices is well known to those skilled in the art, therefore, further discussion of the polarizers 13 and 18 has been omitted for the sake of brevity.

The transflector portions 12 and 20 can be formed, for example, from an electrochromic material or a polymer dispersed liquid display material. The electrochromic material or the polymer dispersed liquid display material can be utilized to provide a cell that is in one of a substantially clear state or a reflective semi-opaque state. These types of cells can change color upon an application of a voltage to the cell. For example, in the case of an electrochromic cell (EC), when there is no voltage applied to the cell, the cell is optically clear. When a DC voltage is applied to the cell, the cell turns into a semi-opaque color state, which is reflective. An EC can be selected to provide a clear state and a colored state where the color can be one of blue, green, black and white. Additionally, cells of varying colors may be stacked to provide a multicolored transflector portion.

In one aspect of the invention, a white EC is provided for each transflector portion 12 and 20. The LCD cell 14 is sandwiched between the polarizers 13 and 18, and the transflector portions 12 and 20. Applying a voltage V_1^+ to the first transflector portion 12 and not to the second transflector portion 20 causes the first transflector portion 12 to become semi-opaque and reflective and the second transflector portion 20 to become clear or transparent. Therefore, incident light passing through the second transflector portion 20 is reflected back by the first transflector portion 12 to allow viewing of the LCD cell 14 through the second transflector portion 20. Alternatively, applying voltage V_2^+ to the second transflector portion 20 and not to the first transflector portion 12 causes the second transflector portion 20 to become semi-opaque and reflective and the first transflector portion 12 to become clear. Therefore, incident light passing through the first transflector portion 12 is reflected back by the second transflector portion 20 to allow viewing of the LCD cell 14 through the first transflector portion 12.

FIG. 2 illustrates an application of the double-sided viewable display to a portable communication device 30. The portable communication device 30 includes a top portion 32 having a double-sided viewable display 34 with a front surface 40 and a rear surface 42 (FIG. 4). The portable communication device 30

also has a bottom portion 36 with a keypad 38 for inputting information into the portable communication device 30. The portable communication device 30 has an open state as illustrated in FIG. 2 and a closed state as illustrated in FIG. 4. The text illustrated on FIG. 2 is displayed on the front surface 40 of the display 34 when the portable communication device is in its open state. As can be seen in FIG. 3, the first transreflector portion 12 (disposed on the rear) is in a semi-opaque or reflective state and the second transflector portion 20 (disposed on the front) is in a clear or transparent state during display of the text from the front surface 40. The text is displayed on the rear surface 42 (FIG. 4) of the display 34 when the portable communication device 30 is in its closed state as can be seen in FIG. 4. As illustrated in FIG. 5, the second transreflector portion 20 is in a semi-opaque or reflective state and the first transflector portion 12 is in a substantially clear or transparent state during display of the text from rear surface 42.

FIG. 6 illustrates an example of a drive system 50 employed to provide similar displaying on either the front surface 40 or the rear surface 42 of the double-sided display 34. An LCD drive circuitry component 58 provides drive signals to a drive inverter component 56 and a drive selection component 54 for providing drive signals to LCD cells on the double-sided display 34. The drive inverter component 56 provides inverted and synchronized signals such that textual and graphical content are displayed on the rear surface 42 of the display 34, similar to how it appears on the front surface 40 when the double-sided display 34 receives drive signals from the LCD drive circuitry component 58 directly. The inverted drive signals are preferably provided employing logic circuitry such as a programmable logic device (PLD), but alternatively could be accomplished by unique programming instructions or the like. The inverted drive signals are inverted over two axes as opposed to a single axis, as would be employed in a mirror reflection device. Implementation of the inverted drive signals from the LCD drive circuitry 58 can be easily facilitated by one skilled in the art.

Both the LCD drive circuitry signals and the inverted LCD drive circuitry signals are inputted into the drive selection component 54. The drive selection component 54 switches between

transmitting the drive circuitry signals and the inverted drive circuitry signals to the double-sided display 34 based on the state of a display position switch 52. The display position switch 52 changes state upon changing the portable communication device to between the open state and the closed state. The display position switch 52 is coupled to the doubled sided display 34 and determines which of the transflector portions 12 and 20 will be semi-opaque (provided with a voltage potential) for providing reflecting and which will be substantially clear (not provided with a voltage potential) for providing viewing.

In one aspect of the invention, the double-sided display 34 may provide displaying of an image and/or textual contents on both sides of the display 34 by switching between transflector portions 12 and 20 and simultaneously switching between drive input signals and inverted drive input signals. For example, by inputting a square wave signal in the range of 250-350 HZ to the display position switch 52 output, it is possible to provide viewing on both sides of the display 34 concurrently. An alternating switch signal will allow alternating the first transflector portion 12 between a semi-opaque and a substantially clear state, while second transflector 20 alternates between a clear and semi-opaque state. The alternating switch signal also provides multiplexing of the drive input signals and inverted drive input signals through the drive selection component 54.

In another aspect of the invention, a single transflector portion is employed for providing a display having a displaying state and a substantially clear transparent state. For example, this type of implementation may find applicability in a retail market such as a jewelry store where information on a product may be viewed in a display state and the product may be viewed in the clear transparent state. Referring to FIGS. 7 and 8, a single sided display 60 is provided having an LCD cell 64 disposed between a first polarizer 62 and a second polarizer 66. A single transflector portion 68 is provided on one side of the LCD cell 66. The single transflector portion 68 can be formed from an electrochromic material or a polymer dispersed liquid display material. The electrochromic material or the polymer dispersed liquid display material can be utilized to provide a cell that is in one of a substantially clear state or a semi-opaque state.

These types of single transflector portion 68 can change color upon an application of a voltage to the cell. For example, in the case of an electrochromic cell (EC), when there is no voltage applied to the cell, the cell is optically clear. If a DC voltage is applied to the cell, the cell turns into a semi-opaque color state, which is reflective. An EC can be selected to provide a clear state and a colored state where the color can be one of blue, green, black and white. Additionally, cells of varying colors may be stacked to provide a multicolored transflector portion.

In one aspect of the invention, a white EC is provided for the single transflector portion 68. In a clear state, where voltage V_3^+ is not applied as illustrated in FIG. 7, the light transmits through the front and rear surfaces of single sided display 60 and provides a clear view of an object (or objects) on the opposite side of the display in other words, the display becomes a transparent window. In an opaque state, where voltage V_3^+ is applied as illustrated in FIG. 8, the light does not transmit through the single sided display but passes through the front surface and is reflected back to display an image generated by the LCD cell 64.

In view of the structure described above with respect to FIGS. 1-8, a methodology for employing a transflector in an LCD device where the transflector has a selectable state between a reflective state and a transparent state may be better appreciated with respect to the flow diagrams of FIGS. 9-10. While, for purposes of simplicity of explanation, the methodologies of FIGS. 9-10 is shown and described as a series of steps, it is to be understood and appreciated that the present invention is not limited to the order of steps, as some steps may, in accordance with the present invention, occur in different orders and/or concurrently with other steps from that shown and described herein. Moreover, not all illustrated steps may be required to implement a methodology in accordance with an aspect of the present invention.

Referring to FIG. 9, a methodology for operating the double sides display illustrated in FIGS. 1-6 is provided. The methodology begins at step 100 where power is provided to the device having the double-sided display. In step 110, the device

determines whether or not the device has powered up in the first state. For example, the first state is where a portable communication device is in an open state as illustrated in FIG. 2, while a second state is where the portable cellular communication device is in its closed state. When the device is in a first state (YES), voltage is applied to a first transflector portion and voltage is removed from a second transflector portion at step 120 for providing viewing from a first side of the double-sided display. At step 130, LCD drive signals are transmitted to the LCD cell. The device then continuously monitors whether or not the device is still in the first state at step 140. When the device is no longer in the first state in either step 110 or step 140 (NO), the device has entered a second state and advances to step 125. At step 125, the device applies voltage to the second transflector portion and voltage is removed from the first transflector portion for providing viewing from a second side of the double-sided display. At step 135, inverted LCD drive signals are then transmitted to the LCD cell. The device then continuously monitors whether or not the device is in the second state at step 145. If the device is not in the second state (NO), the device has moved to the first state and the device advances to step 120, otherwise the device remains in the second state.

Referring to FIG. 10, a methodology for operating the single sided display illustrated in FIGS. 7-8 is provided. The methodology begins at step 200 where power is provided to the device having the single sided display. In step 210, the device determines whether or not the device has powered up in the first state. For example, the first state is where the single sided display provides information relating to a product residing underneath the single sides display such as illustrated in FIG. 8, while a second state is where the single sided display provides a clear window for viewing the product residing underneath the single sided display as illustrated in FIG. 7. If the device is in a first state (YES), voltage is applied to a transflector portion at step 220 for providing viewing of information on the single sided display. At step 230, LCD drive signals are transmitted to the LCD cell. The device then continuously monitors whether or not the device is still in the first state at step 240. If the device is not in the first state in either step

210 or step 240 (NO), the device has entered a second state and advances to step 225. At step 225, the device removes the voltage that is applied to the transflector portion for providing a clear view of a product on the other side of the single sided display. At step 235, transmission of the LCD drive signals are disabled. The device then continuously monitors whether or not the device is in the second state at step 245. If the device is not in the second state (NO), the device has moved to the first state and the device advances to step 220, otherwise the device remains in the second state.

What has been described above includes one or more examples of the present invention. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the present invention, but one of ordinary skill in the art will recognize that many further combinations and permutations of the present invention are possible. Accordingly, the present invention is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the terms "includes" and variations thereof and "having" and variations thereof are used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising."

What is claimed is:

CLAIMS

1. A LCD system, comprising:

an LCD cell having a front surface and a rear surface;

a first transflector portion disposed on the front surface, the first transflector portion being switchable between a reflective state and a transparent state; and

a second transflector portion layer disposed on the rear surface, the second transflector portion being switchable between a reflective state and a transparent state,

2. The system of claim 1, the front surface of the LCD cell being viewable when the first transflector portion is in a transparent state and the second transflector portion is in a reflective state and the rear surface of the LCD cell layer being viewable when the second transflector portion is in a transparent state and the first transflector portion is in a reflective state.

3. The system of claim 1, the first and second transflector portions being controllable between the reflective state and the transparent wherein a potential applied to electrodes of the corresponding transflector portion causes the corresponding transflector portion to switch from the transparent state to the reflective state.

4. The system of claim 1, the first and second transflector portions comprising an electrochromic material.

5. The system of claim 1, at least one of the first and second transflector portions comprising a plurality of stacked materials of varying colors.

6. The system of claim 1, the first and second transflector portions comprising a polymer dispersed liquid display material.

7. The system of claim 1, further comprising a drive inverter component operable to invert and synchronize signals from an LCD drive circuit and a selection component operable to transmit drive signals to the LCD cell layer in a first state for displaying the front surface of the LCD cell and inverted drive signals to the LCD cell in a second state for displaying the rear surface of the LCD cell.

8. The system of claim 7, the drive inverter component inverting the drive signals over two axes.

9. The system of claim 1, further comprising a display position switch operable to switch the system between a first state for displaying the front surface of the LCD cell and a second state for displaying the rear surface of the LCD cell.
10. The system of claim 9, the display position switch being further operable to alternate between the first state and the second state at a frequency of 250-350 hertz for displaying the front and the rear surface of the LCD cell concurrently.
11. The system of claim 1, the LCD system residing on a portable communication device wherein the portable communication device has an open position for displaying the front surface of the LCD cell and a closed position for displaying the rear surface of the LCD cell.
12. The system of claim 11, further comprising a display position switch operable to monitor the position of the portable communication device wherein the open position causes the LCD system to enter the first state and the closed position causes the LCD system to enter the second state.
13. A LCD system, comprising:
an LCD cell having a front surface and a rear surface; and
a transflector portion disposed on the rear surface, the transflector portion being switchable between a reflective state and a transparent state.
14. The system of claim 13, wherein the LCD system has a first state for displaying an image generated by the LCD cell and a second state for providing a transparent window.
15. The system of claim 13, the transflector portion being in the reflective state when a potential is applied to electrodes coupled to the transflector portion and being in the transparent state when no potential is applied to the electrodes.
16. The system of claim 13, the transflector portion comprising an electrochromic material.
17. The system of claim 12, the transflector portion comprising a plurality of stacked materials of varying colors.
18. The system of claim 12, the transflector portion comprising a polymer dispersed liquid display material.
19. The system of claim 12, wherein light passes through the front surface and is reflected by the transflector portion in a first state for displaying an image generated by the LCD cell

layer and light passes through the front surface and the rear surface of the LCD cell in a second state for providing a transparent layer for viewing objects residing behind the rear surface from the front surface.

20. The system of claim 12, further comprising a position switch operable to switch the transflector portion between the reflective state and the transparent state.

21. A portable communications device including the system of claim 12.

22. A method for viewing material on an LCD system having a transflector portion activatable between a reflective state and a transparent state, the transflector portion being disposed on a surface of an LCD cell, the method comprising the steps of:

determining a state of the LCD system;

selecting one of the reflective state and the transparent state of the transflector portion based on the state of the LCD system; and

switching to the other of the reflective state and the transparent state of the transflector portion.

23. The method of claim 22, the transflector portion being a first transflector portion disposed on a front surface of the LCD cell and a second transflector portion being disposed on a rear surface of the LCD cell wherein the LCD system has a first state for displaying the front surface of the LCD cell through the first transflector portion and a second state for displaying the rear surface of the LCD cell through the second transflector portion.

24. The method of claim 23, further comprising the steps of applying a potential to the second transflector portion and not the first transflector portion in the first state and applying a potential to the first transflector portion and not the second transflector portion in the second state.

25. The method of claim 24, further comprising providing drive signals to the LCD cell layer in the first state and providing inverted drive signals to the LCD cell layer in the second state.

26. The method of claim 25, further comprising a step of alternating between the first and a second states to concurrently display the front surface of the LCD cell through the first transflector portion and the rear surface of the LCD cell through the second transflector portion.

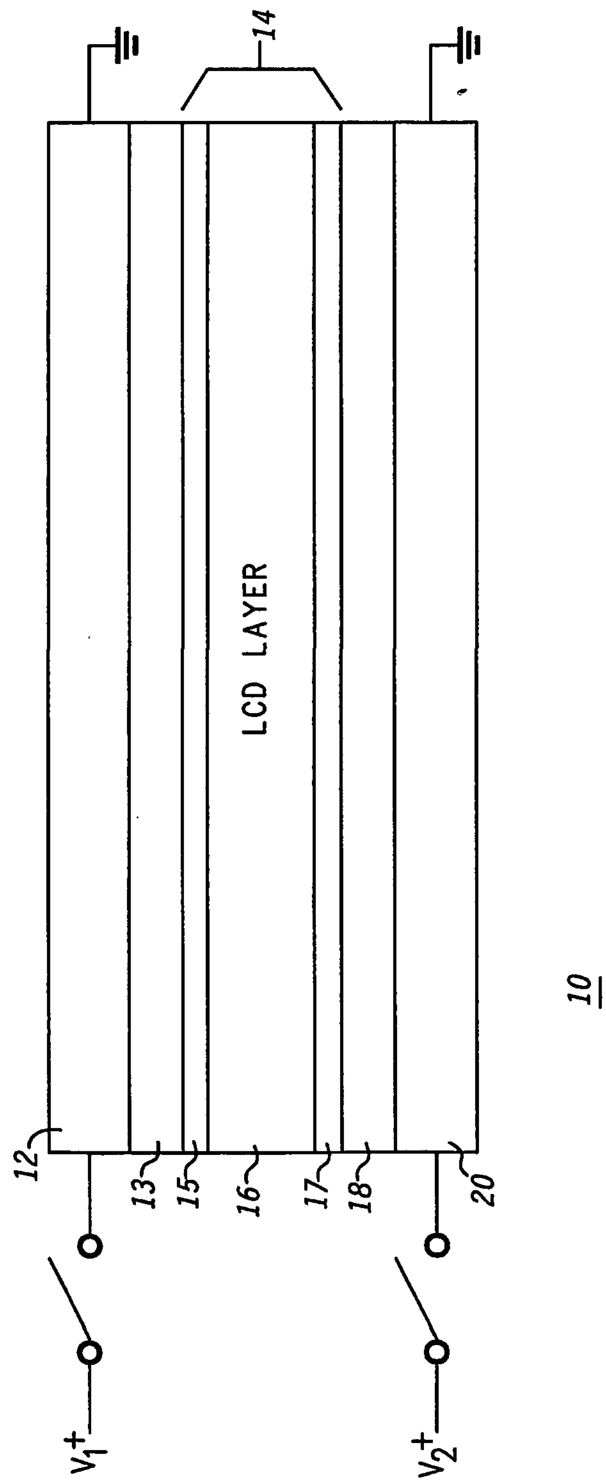


FIG. 1

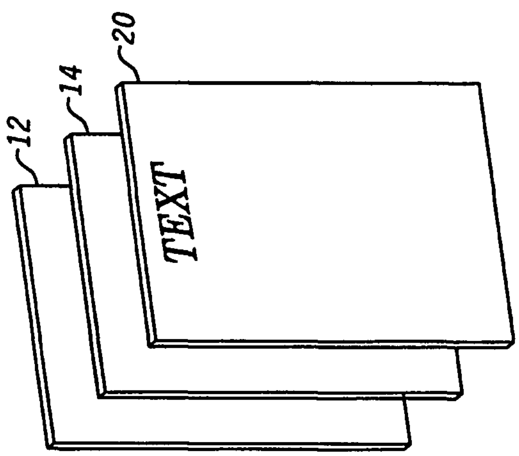

12
14
20
TEXT

FIG. 3

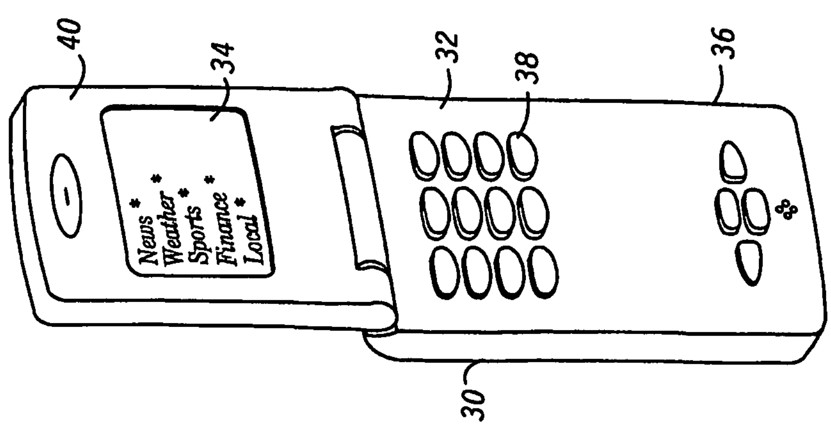

40
34
32
38
36
30
News *
Weather *
Sports *
Finance *
Local *

FIG. 2

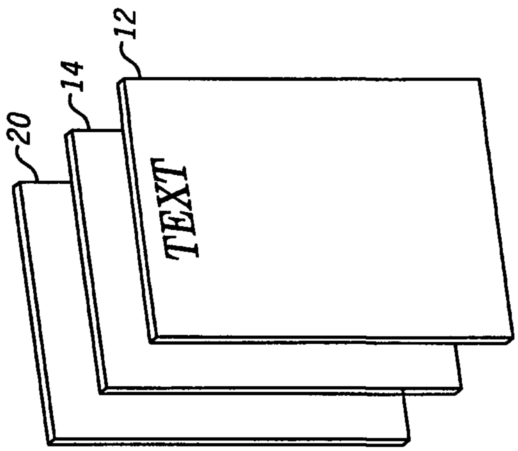


FIG. 5

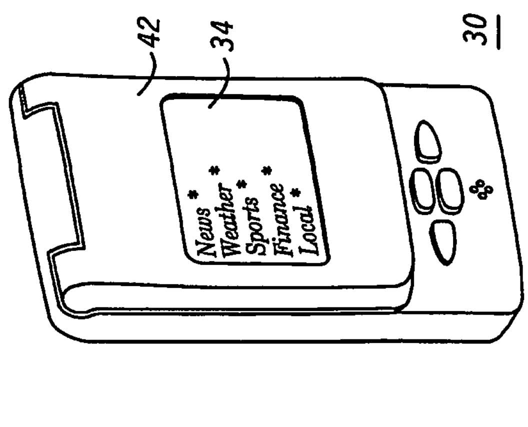


FIG. 4

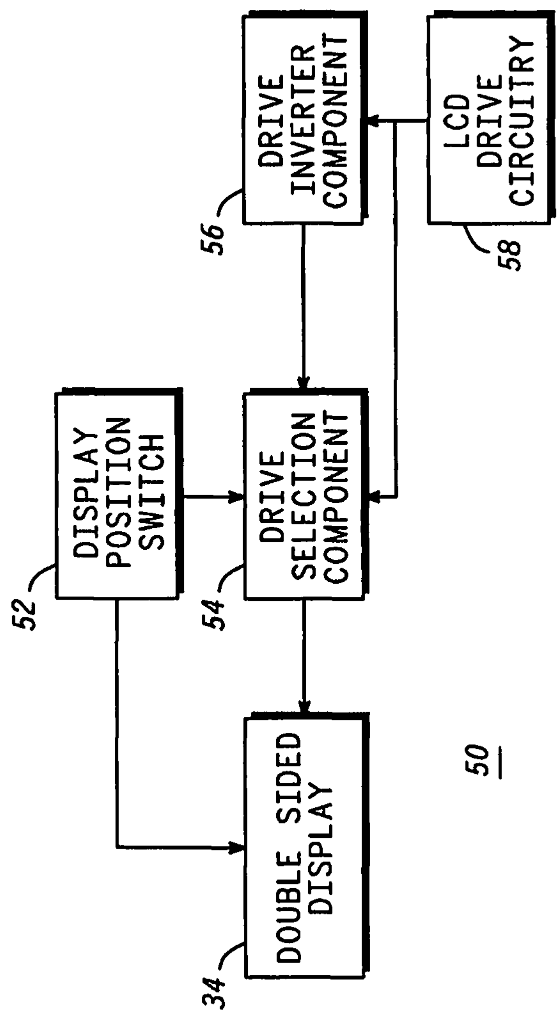

DRIVE INVERTER COMPONENT
LCD DRIVE CIRCUITRY
DISPLAY POSITION SWITCH
DRIVE SELECTION COMPONENT
DOUBLE SIDED DISPLAY
56
58
52
54
34
50

FIG. 6

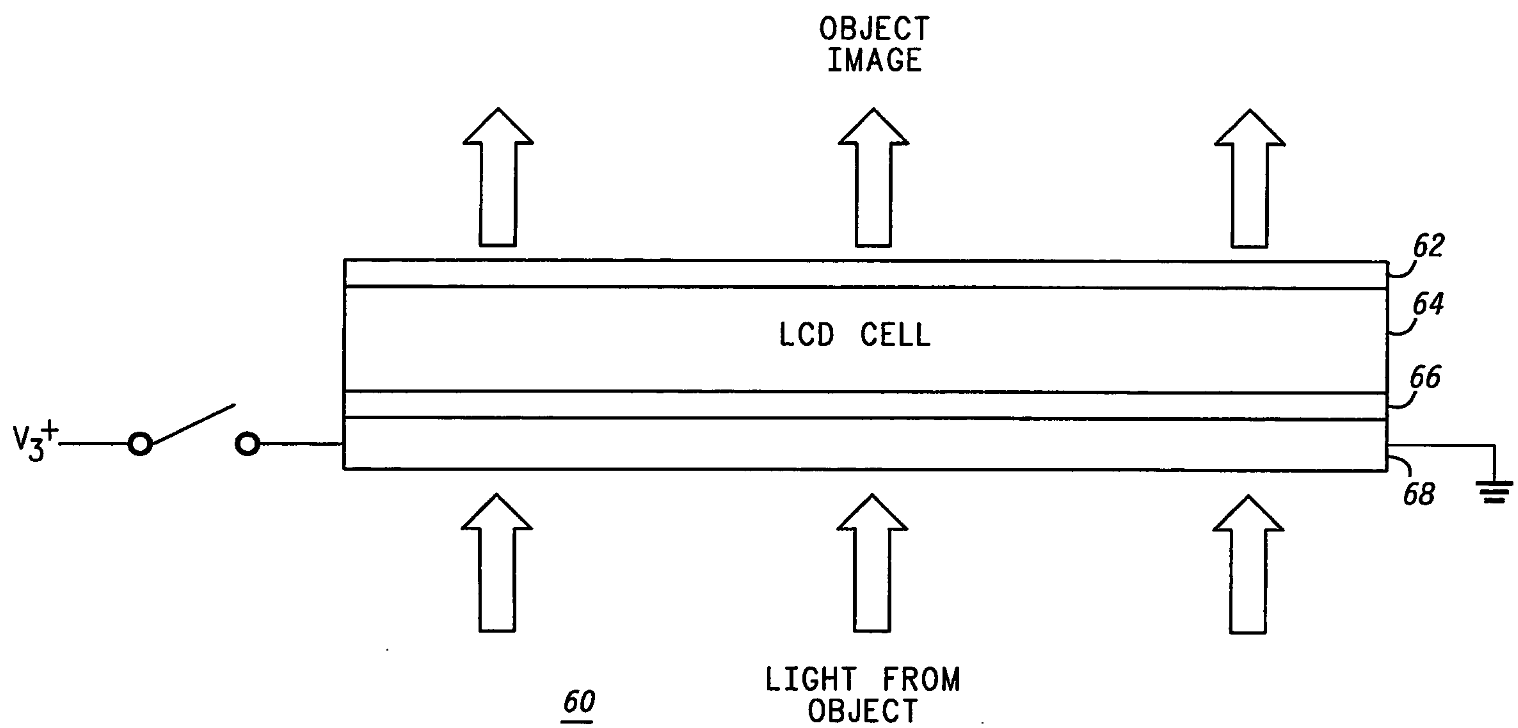


FIG. 7

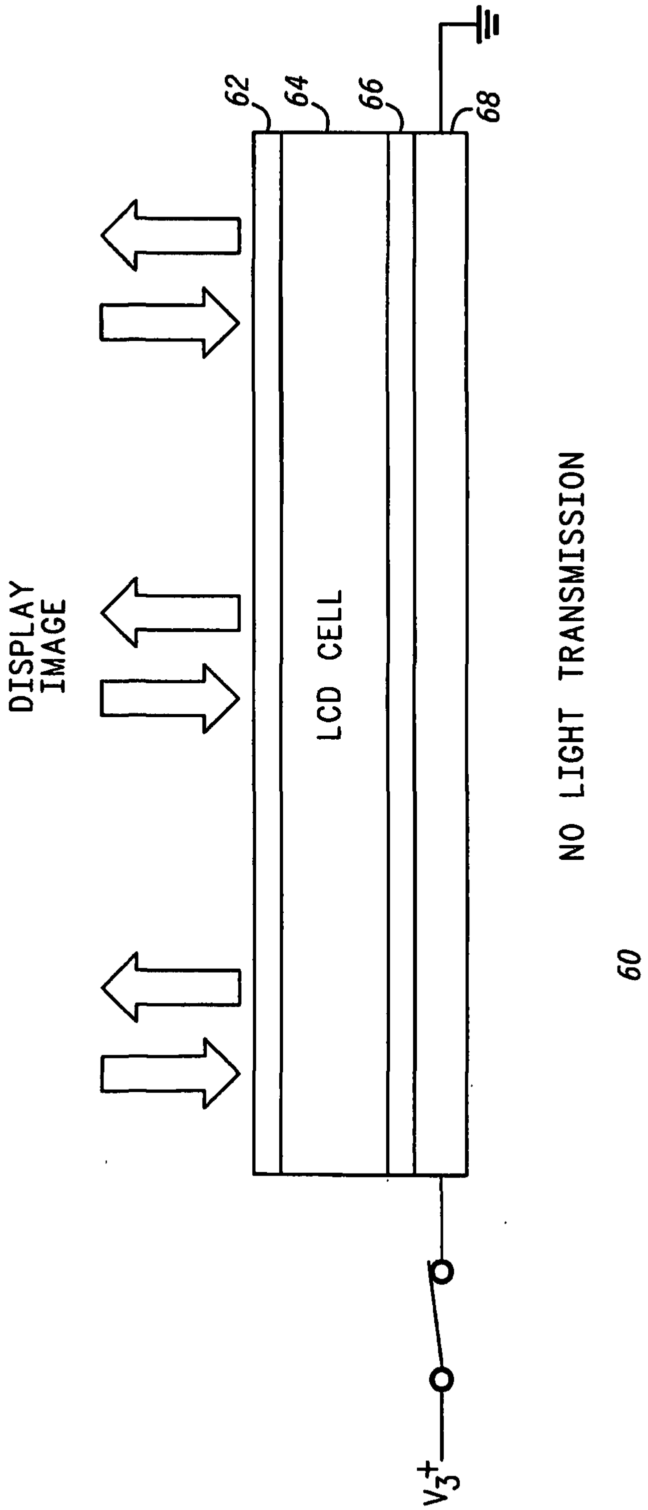

62
64
66
68
DISPLAY IMAGE
LCD CELL
NO LIGHT TRANSMISSION
60
V_3^+

FIG. 8

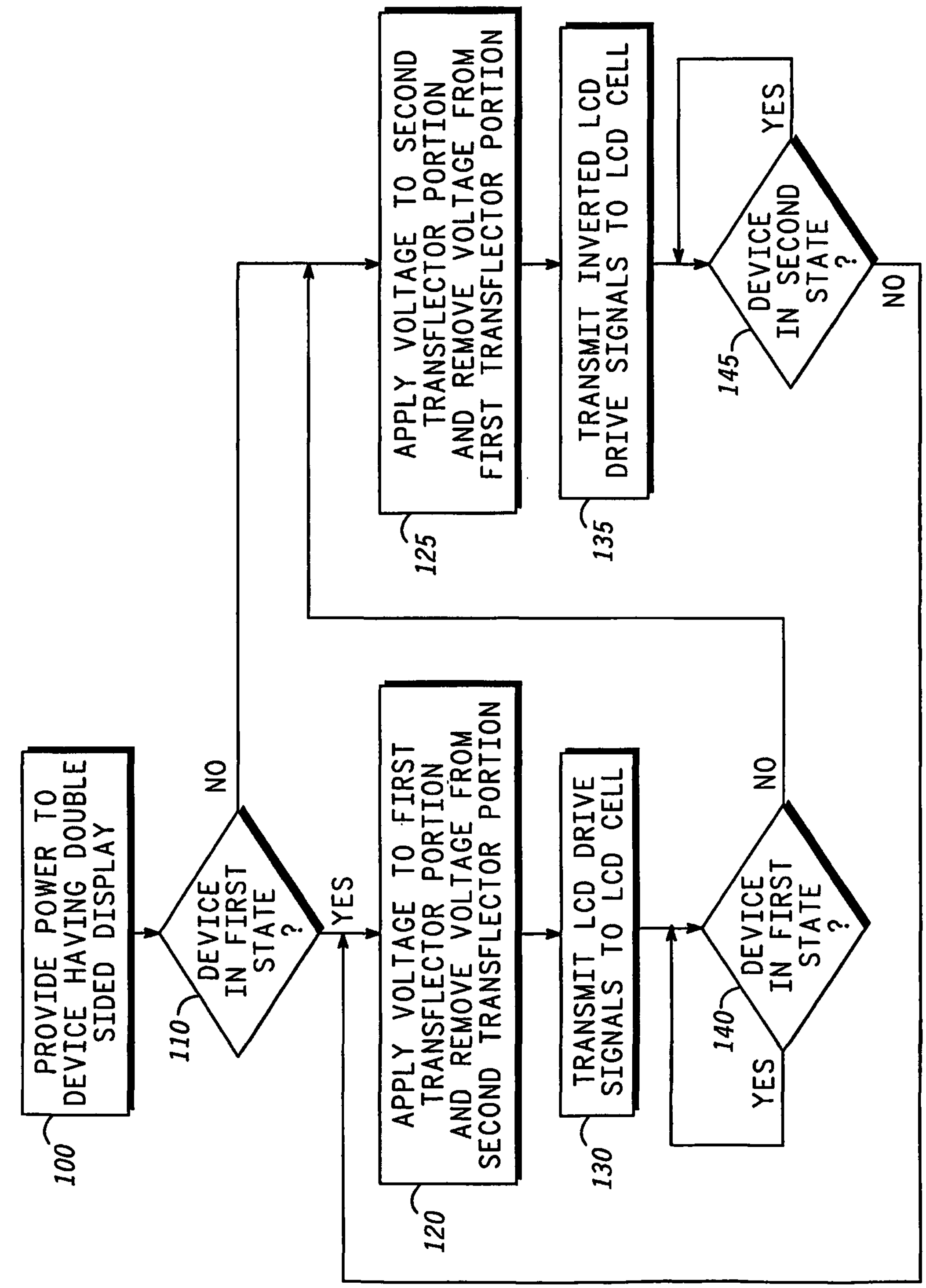

PROVIDE POWER TO DEVICE HAVING DOUBLE SIDED DISPLAY
100
DEVICE IN FIRST STATE ?
110
YES
NO
APPLY VOLTAGE TO FIRST TRANSFLECTOR PORTION AND REMOVE VOLTAGE FROM SECOND TRANSFLECTOR PORTION
120
TRANSMIT LCD DRIVE SIGNALS TO LCD CELL
130
DEVICE IN FIRST STATE ?
140
YES
NO
APPLY VOLTAGE TO SECOND TRANSFLECTOR PORTION AND REMOVE VOLTAGE FROM FIRST TRANSFLECTOR PORTION
125
TRANSMIT INVERTED LCD DRIVE SIGNALS TO LCD CELL
135
DEVICE IN SECOND STATE ?
145
YES
NO

FIG. 6

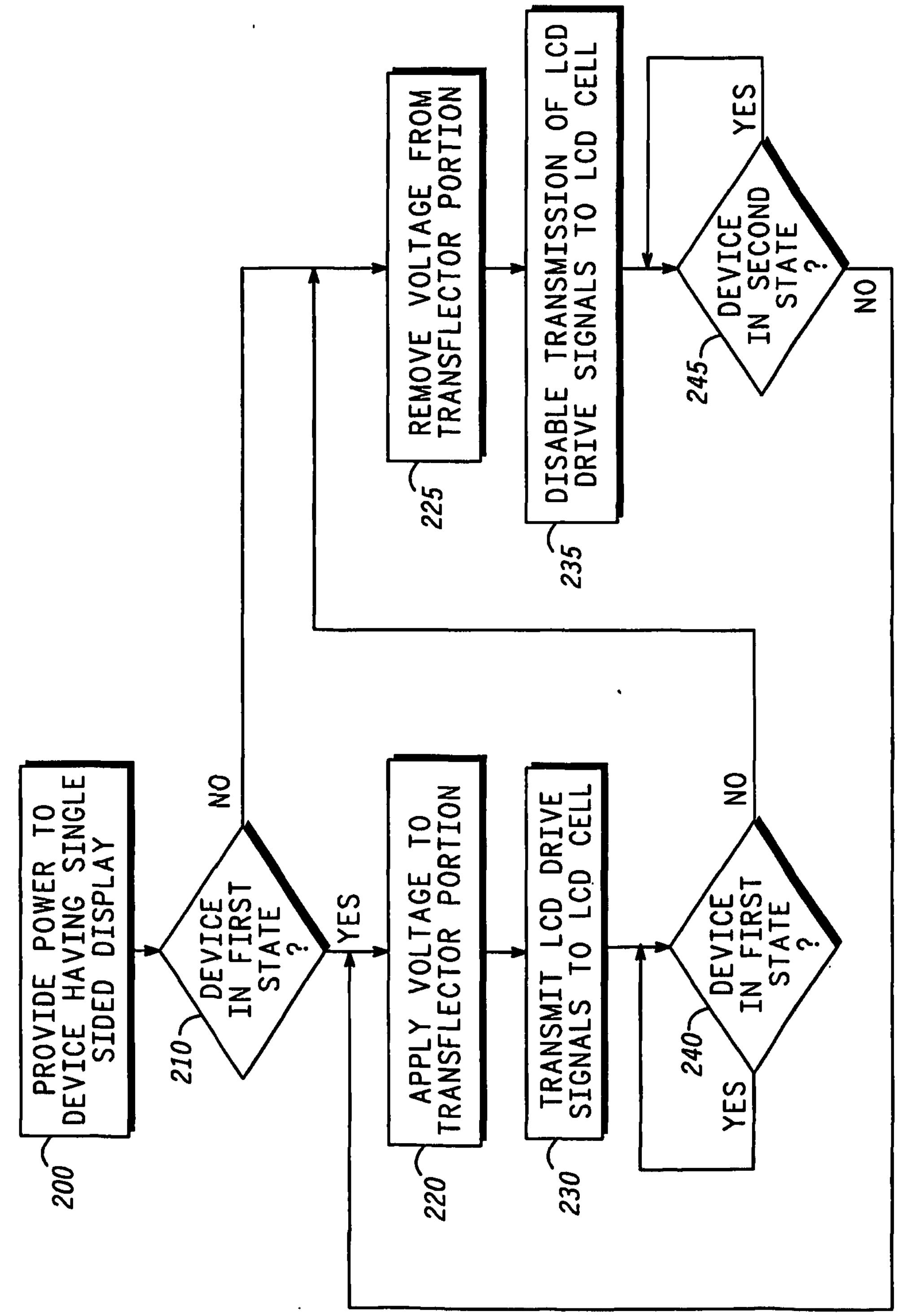

PROVIDE POWER TO DEVICE HAVING SINGLE SIDED DISPLAY
200
DEVICE IN FIRST STATE ?
210
NO
YES
APPLY VOLTAGE TO TRANSFLECTOR PORTION
220
TRANSMIT LCD DRIVE SIGNALS TO LCD CELL
230
DEVICE IN FIRST STATE ?
240
YES
NO
REMOVE VOLTAGE FROM TRANSFLECTOR PORTION
225
DISABLE TRANSMISSION OF LCD DRIVE SIGNALS TO LCD CELL
235
DEVICE IN SECOND STATE ?
245
YES
NO

FIG. 10